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The Lithology of Herman and Campbell Beach of Glacial Lake Agassiz in the Area of Larimore and Arvilla, North Dakota

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THE LITHOLOGY OF HERMAN AND CAMPBELL BEACH OF GLACIAL LAKE AGASSIZ IN THE AREA OF LARIMORE AND ARVILLA, NORTH DAKOTA

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ABSTRACT

The lithology of Herman and Campbell beaches of Glacial Lake Agassiz was studied in this report. It was found that the beaches are similar in that the material is 30 to 50 percent by weight over 4 mm. in diameter in both beaches. No shale is present in the sand of Campbell, although there is some in the coarser material. The heavy minerals found in both beaches are: magnetite, ilmenite, biotite, amphibole, tourmaline, and hyalophane.

INTRODUCTION

The purpose of this report is to describe the lithology of Herman and Campbell beaches in the area around Larimore, and Arvilla, North Dakota. Several other beaches are present in the area, but no study was made of them.

Location of the Area:

Arvilla is 23 miles west of Grand Forks and Larimore is six miles west of Arvilla. Both towns are located in the Larimore quadrangle, which is between 97°30' and 97°45' west longitude, and between 47°45' and 48°00' north latitude in the central part of Grand Forks County. The larimore quadrangle is on the old west shore of Glacial Lake Agassiz, which once occupied the Red River Valley (Fig. 1). One of the gravel pits in the Campbell beach which was studied is one mile northeast of Arvilla and is in the adjacent Emerado quadrangle.

Methods of Study:

Samples were collected from six different gravel pits in the two beaches studied. The samples were split down until 300 to 700 grams remained, depending on the relative coarseness of the gravel, and then placed in the following Tyler screens: 5 mesh (3.96 mm.), 9 mesh (1.98 mm.), 16 mech (0.991 mm.), 32 mesh (0.495 mm.), 60 mesh (0.246 mm.), 115 mesh (0.124 mm.), 250 mesh (0.061 mm.), and the bottom pan. These screens were used to place the samples into Wentworth's (1922), size classification. The samples were

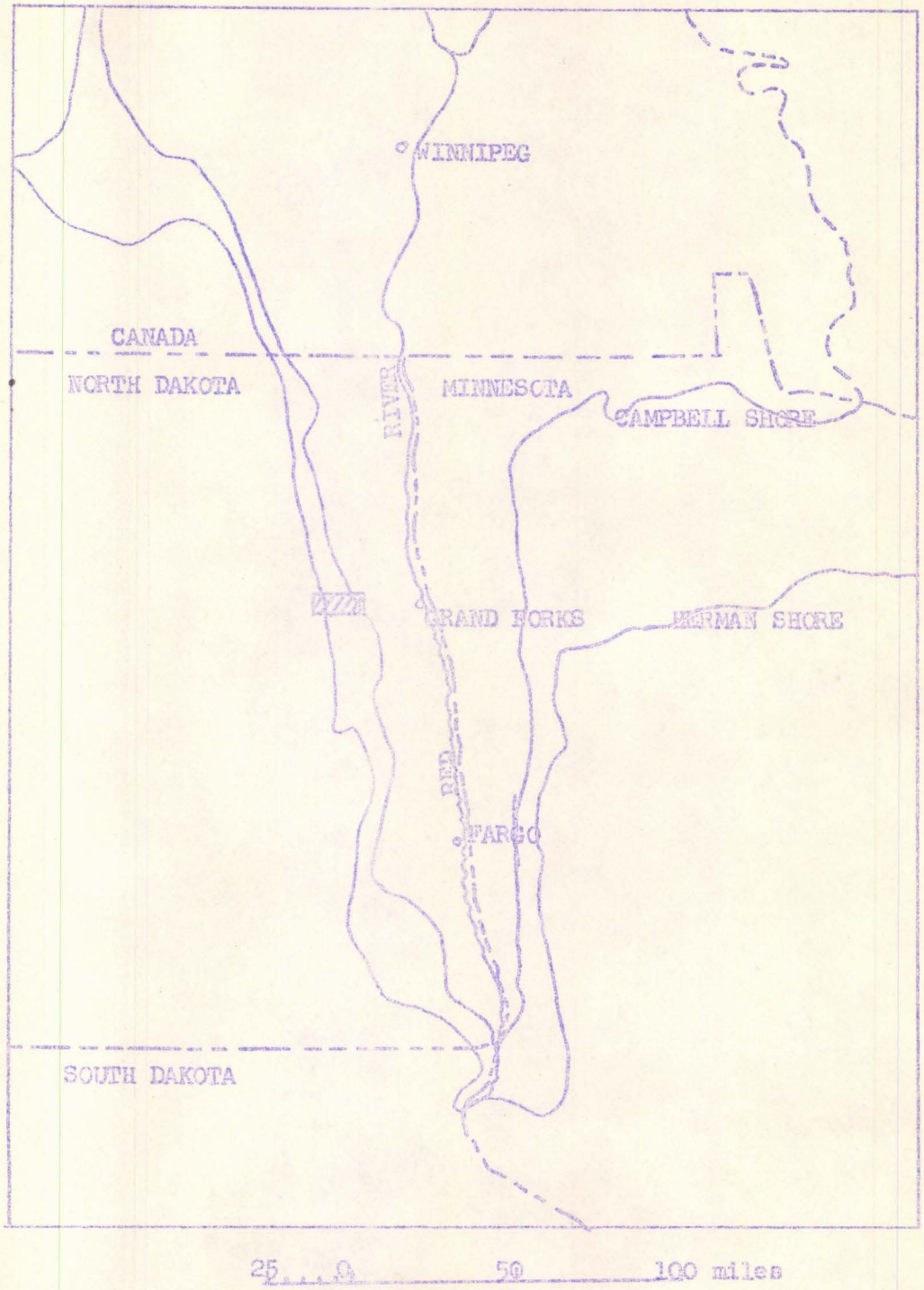


Fig. 1. Map showing Herman and Campbell shore lines of Lake Agassiz, and area of report.
(from Leverett, 1932.)

shaken in the Tyler automatic "Ro-tap" for a period of ten minutes. After shaking the weight percentage of material in each class was calculated.

Material in the 1/8 mm. to 1 mm. range was used for the heavy mineral separation. The heavy minerals were separated with bromoform and identified under a microscope.

The material in the same range was divided down until a few hundred grains remained. A shale and quartz percentage by grain count was made.

HISTORY OF LAKE AGASSIZ

The Red River Valley was once occupied by Glacial Lake Agassiz. The area of the lake was approximately 110,000 square miles, the length was 700 miles; and its maximum width was more than 250 miles. The greatest depth was about 200 feet above the present level of Lake Winnipeg (Upham, 1895, p. XXI).

Of the several schools of thought in regard to the history of Lake Agassiz, Upham (1895), and Leverett (1932), essentially agree on the same formation. They hold that the lake grew from south to north as fast as the ice receded out of the valley. The beaches were formed along the shores of the lake at different levels as the lake level dropped. The first and highest beach is the Herman. The lake was drained originally to the south through the River Warren, then as the ice receded past the international

boundary lower outlets were formed to the northeast. Finally the outflow was into Hudson Bay and Lake Agassiz dropped to the present level of Lake Winnipeg.

Tyrell (1895), and Johnston (1932), believe that Lake Agassiz had, at first, a small beginning in the Red River Valley and rose until it overflowed to the south. The cause of the lake was the readvance of the glacier, blocking the northward drainage. After the formation of the upper beaches the lake was partially or wholly drained, and then rose again to a level lower than the Campbell beach. When the ice sheet receded northward drainage was again restored.

As the beaches are traced northward their elevation increases about 180 feet in North Dakota. This increase is the result of the unburdening of the land by the withdrawal of the ice sheet. First, the southern half of the area of Lake Agassiz was uplifted, then the northern half as the southern half was almost at rest (Upham, 1895, p. XXII).

LITHOLOGY OF HERMAN BEACH

The Herman beach, named from Herman, Minnesota, is the highest beach of Lake Agassiz. In the Larimore area there are four stages of the Herman beach, but only the highest one was studied; the other three representing substages of the Herman level. The lithology of the Upper

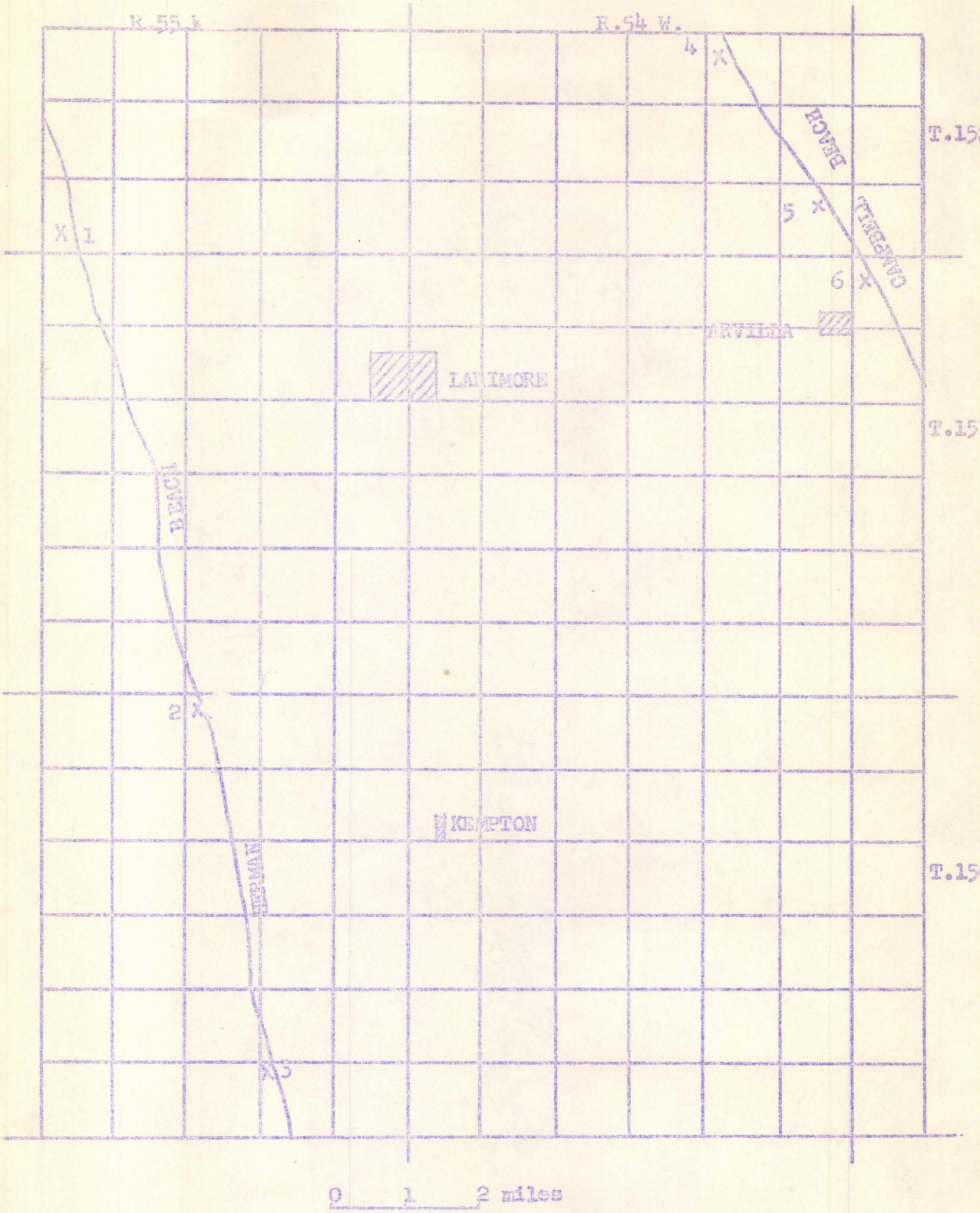


Fig.2. Map of report area showing location of samples.

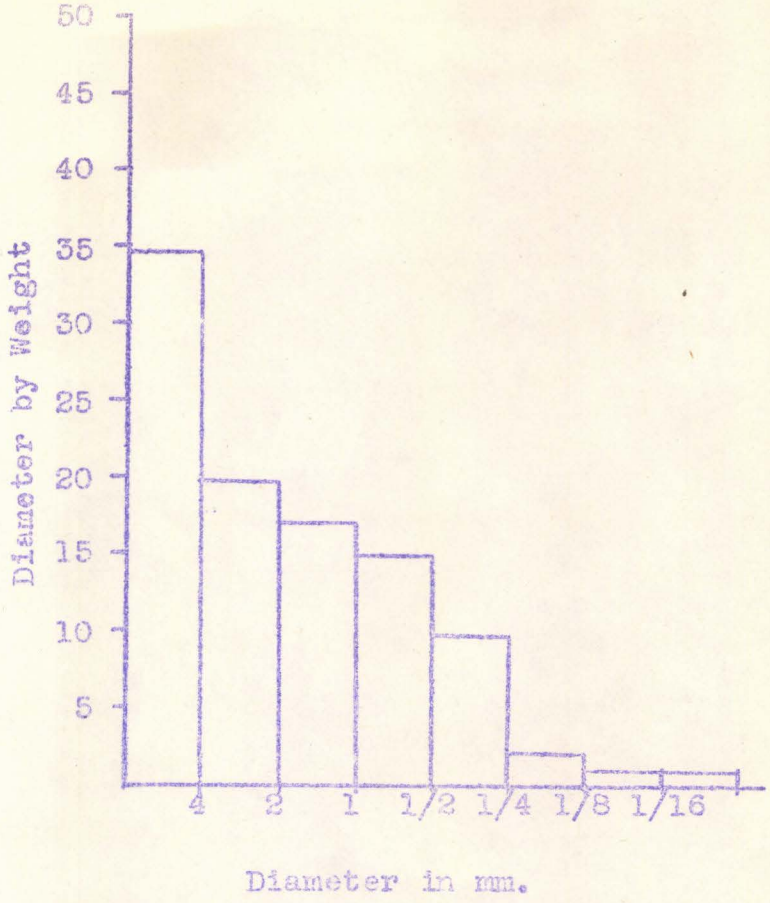
Herman beach will be discussed according to the three locations studied.

The first gravel pit studied is located in the SW¼, SW¼, Sec. 29, T. 152 N., R. 55 W., (Fig. 2). The pit is located on top of a northwest trending ridge which is about 20 feet above the general level to the east. The elevation of this ridge in this area is 1162 feet. The north wall of the pit exposes an eight foot section where the gravel is crudely stratified in the top seven feet and the bottom is finely layered sand. A six foot vertical channel sample was taken for analysis. Table I gives the data used in constructing the graph in Fig. 3.

TABLE I. Data of Mechanical Analysis of Sample No. 1.

Tyler Screen	Weight Retained on Screen	% by Weight
5 mesh	223.32 grams	34.53
9	128.55	19.88
16	110.60	17.10
32	96.65	14.95
60	61.80	9.56
115	13.80	2.13
250	6.00	.93
Pan	5.98	.92
Total	646.70 grams	100.00

The material above the 5 mesh screen goes up to 50 mm. in diameter, with an occasional cobble around 70 mm. in diameter. The material is subrounded to well rounded in the pebble class. In the 1/8 to 1 mm. class the material is mostly angular to subangular and rounded to well rounded, with the subrounded class noticeably small. In



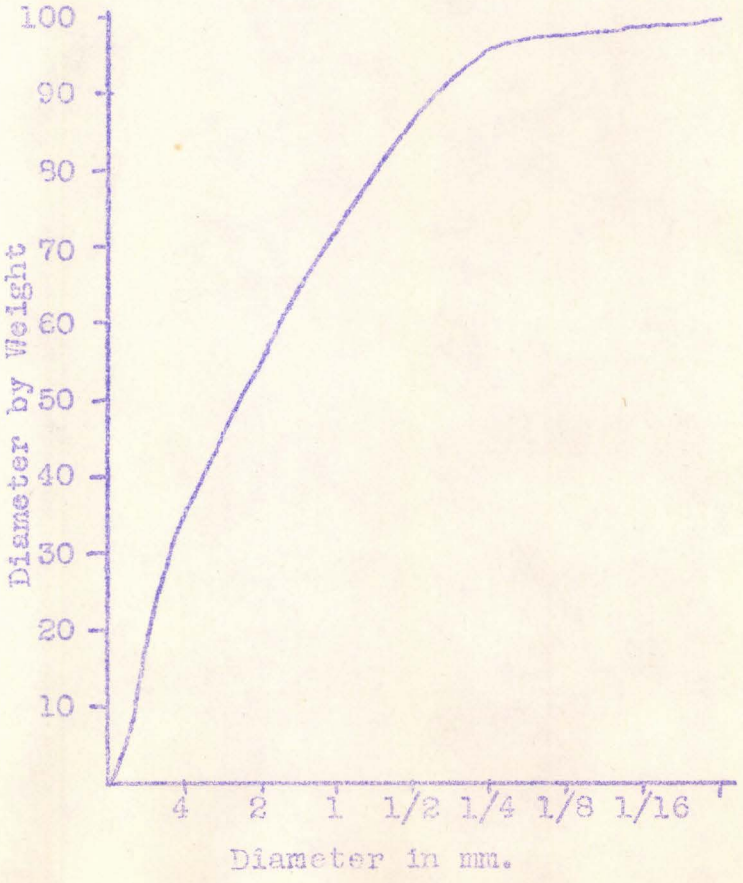


Fig. 3. Histogram and Cumulative Curve of Sample 1.

the rounded to well rounded range the sphericity is up to 0.9.

The sand in the 1/8 to 1 mm. range was split down to 323 grains. Quartz comprised 36.2 percent of the total and shale another 8.9 percent, with the shale increasing as the size increased.

Heavy minerals found consisted of three percent by weight of the sand. The heavy minerals in this sample are: magnetite, ilmenite, amphibole, hyalophane, garnet, zircon, and tourmaline. The light "minerals" consisted mostly of quartz, shale, quartzite, and igneous rocks.

The second gravel pit in the Herman beach that was studied is about nine miles south of the first in the NW¼, NW¼, Sec. 3, T. 150 N., R. 55 W., (Fig. 2). In this area the beach forms a low ridge with an elevation of 1155 feet. A seven foot vertical section was observed in this pit. The top three feet consists of unstratified sand and gravel with a few cobbles up to 70 or 80 mm. in diameter scattered throughout. The next foot consists of a bed of very fine sand and clay, in which the clay is hard and forms a ledge with the fine sand on top. Below the clay is sand and gravel crudely stratified. The material is up to 50 or 60 mm. in diameter. The sample used in the analysis was a five foot vertical channel sample. Table II lists the data for the graph in Fig. 4.

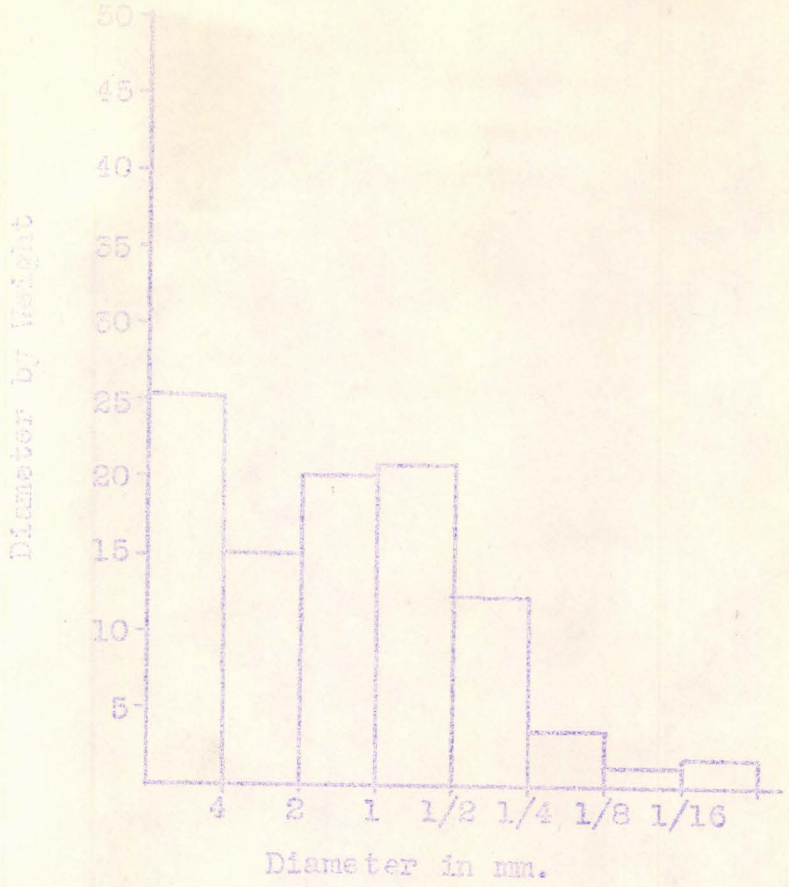
TABLE II. Data for Mechanical Analysis of Sample No. 2.

Tyler Screen	Weight Retained on Screen	% by Weight
5 mesh	83.17 grams	25.31
9	49.68	15.12
16	66.50	20.24
32	68.28	20.78
60	40.30	12.26
115	11.42	3.47
250	3.25	.99
Pan	6.00	1.83
Total	328.60 grams	100.00

In the larger material the roundness is subrounded to well rounded. In the sand size the roundness is angular to subangular, subrounded to a few well rounded. The sphericity is up to 0.9 in the better rounded grains. In a sample from 1/8 to 1 mm. 404 grains were observed of which 44 percent was quartz and 10 percent was shale with the shale increasing as the size increases.

The heavy minerals, 5.5 percent by weight, are: Magnetite, ilmenite, zircon, hyalophane, amphibole, biotite, and tourmaline. The light "material" present is: quartz, shale, quartzite, and basalt.

The third gravel pit studied is five miles south of the second in the NW¼, NW¼, Sec. 35, T. 150 N., R. 55 W., (Fig. 2). Here the beach is a low ridge with an elevation of 1145 feet. The beach has been changed by a small creek which is nearby. This gravel pit is similar to No. 2. The top three feet consists of unstratified sand and gravel. A few particles are up to 60 mm. in diameter. The



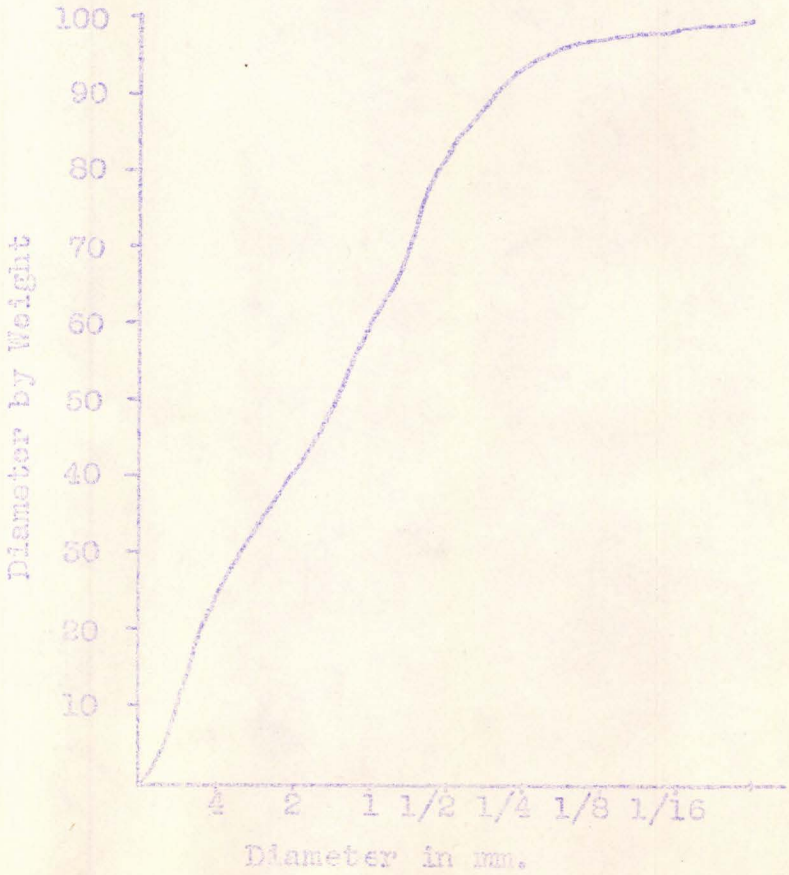


Fig. 4. Histogram and Cumulative Curve of Sample 2.

next one foot is a clay and very fine sand ridge similar to the one in pit No. 2. The very fine sand overlays the clay. Below the clay ledge is sand and gravel crudely stratified and some particles up to 50 mm. in diameter.

TABLE III. Data for Mechanical Analysis of Sample No. 3.

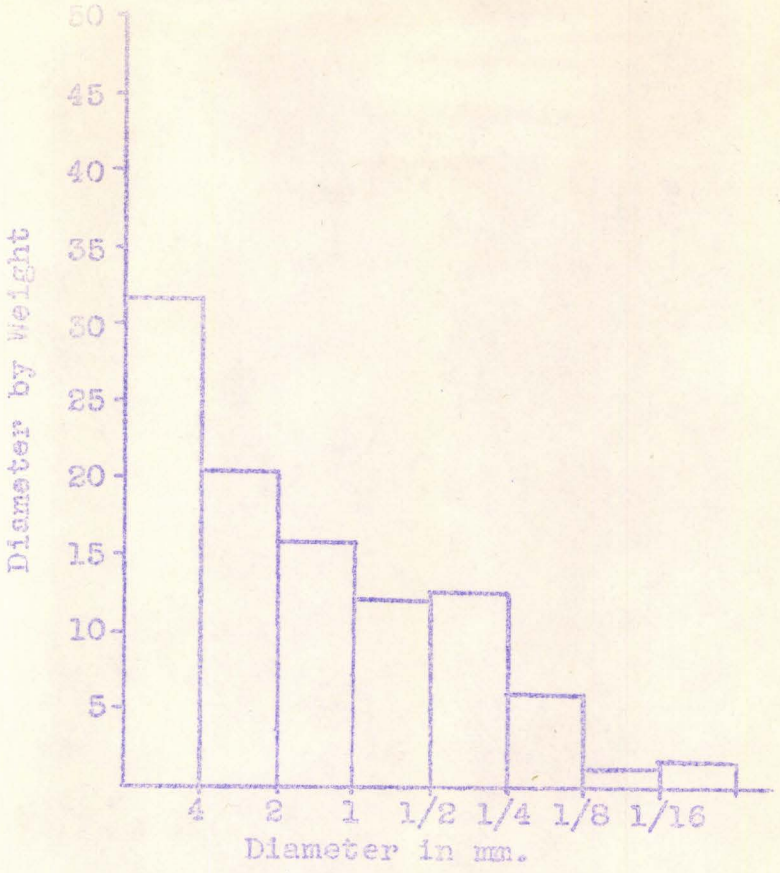
Tyler Screen	Weight Retained on Screen	% by Weight
5 mesh	185.25 grams	31.26
9	120.50	20.33
16	92.70	15.64
32	71.10	12.00
60	74.35	12.55
115	34.23	5.78
250	5.70	.96
Pan	8.78	1.48
Total	592.61 grams	100.00

The coarse material is subrounded to well rounded. The sand is subangular to rounded with some well rounded. The sphericity is up to 0.9. In a count of 460 grains in the 1/8 to 1 mm. range, shale is 4.1 percent and quartz is 66 percent.

The heavy mineral content in the sand range is 5.7 percent, and consists of: magnetite, hyalophane, ilmenite, amphibole, tourmaline, and biotite. The light "material" is: quartz, shale, quartzite, and igneous rock fragments.

THE LITHOLOGY OF CAMPBELL BEACH

The Campbell beach, named after Campbell, Minnesota, is the most outstanding beach lower than the Herman. This beach is marked by an extensive embankment of sand and



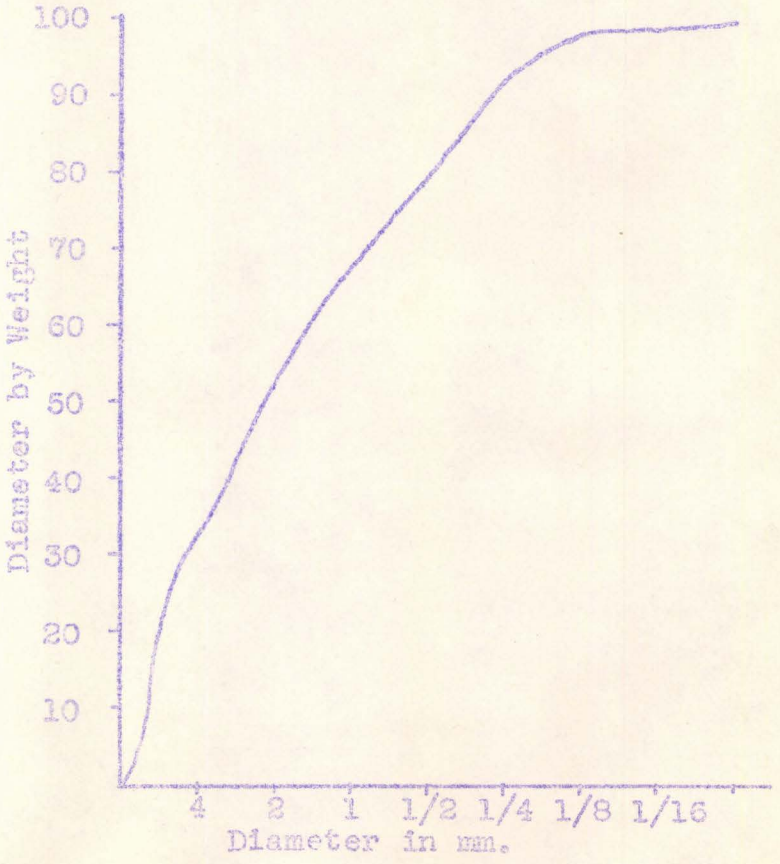


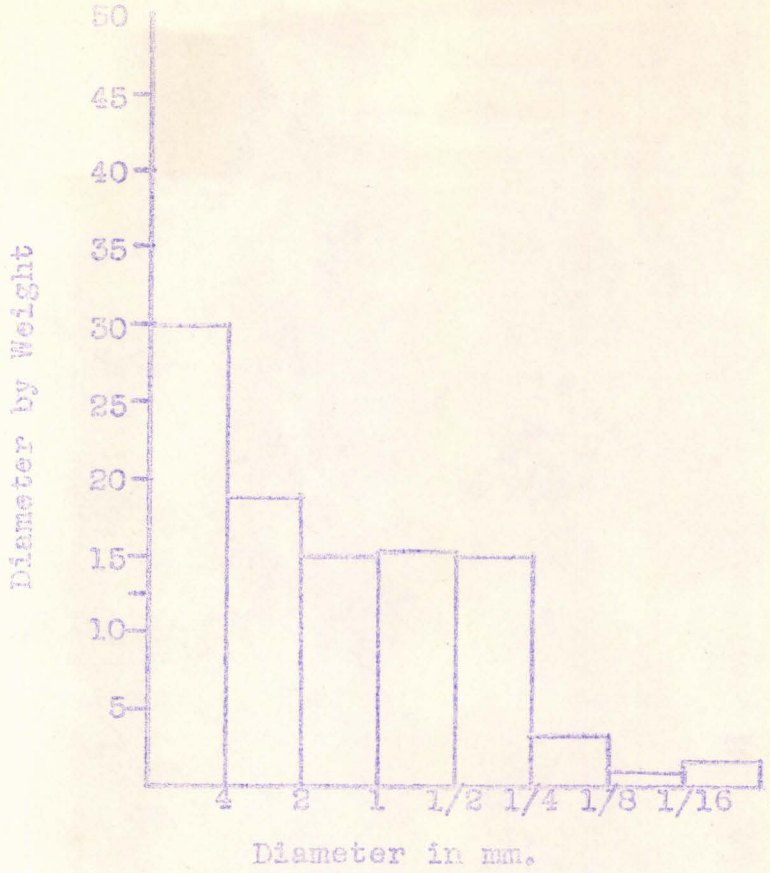
Fig. 5. Histogram and Cumulative Curve of Sample 3.

gravel and in some places by a low, eroded escarpment. The lake was at this level longer than any other level, except possibly the Upper Herman stage (Upham, 1895). In the Arvilla area the Campbell beach is represented by two stages. The lower beach has an elevation of 1000 feet and the upper an elevation of 1010 feet.

Sample No. 4 is from the upper Campbell beach in the SW¼, NW¼, T. 152 N., R. 54 W., (Fig. 2). The beach is a distinct ridge about 10 feet above the general level of the land, and trending to the northwest. This gravel pit is newly opened and exposes a four foot section on the west wall. The beach consists mainly of medium to very coarse sand. The top 14 inches is coarse sand and the next 10 inches is mainly coarse sand with scattered pebbles throughout in crude stratification. The rest of the pit that is uncovered is mainly medium sand. The sample taken at this location is a four foot vertical channel sample. The data is given in Table IV and Fig. 6.

TABLE IV. Data for Mechanical Analysis of Sample, No. 4.

Tyler Screen	Weight Retained on Screen	% by Weight
5 mesh	127.30 grams	30.03
9	79.27	18.70
16	63.62	15.01
32	63.78	15.05
60	63.65	15.02
115	14.70	3.47
250	4.45	1.05
Pan	7.10	1.67
Total	423.87 grams	100.00



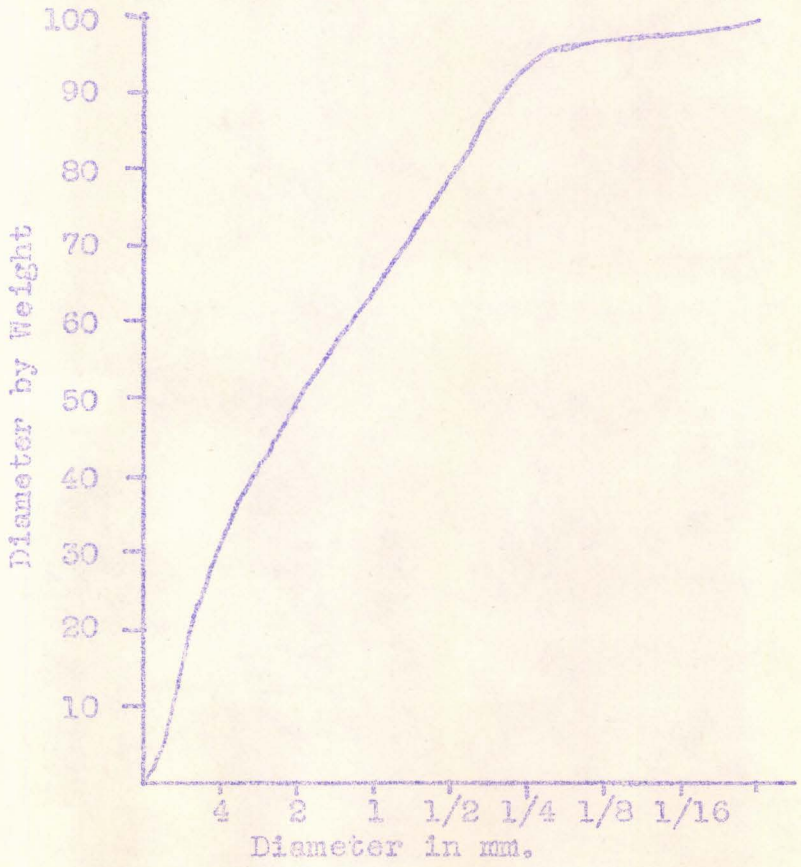


Fig. 6. Histogram and Cumulative Curve of Sample 4.

The larger material is subrounded to well rounded, with a few angular particles. The sphericity is up to 0.8.

In the range of 1/8 to 1 mm., 60.4% of the material is quartz and no shale is present.

The heavy minerals, 4.6 percent by weight, found in the sample are: magnetite, hyalophane, biotite, tourmaline, ilmenite, and amphibole. The light material found is: quartz, quartzite, and igneous rock fragments.

Sample No. 5 is from the upper Campbell beach located in Turtle River State Park, SW$\frac{1}{4}$, NE$\frac{1}{2}$, Sec. 36, T. 152 N., R. 54 W., (Fig. 2). Here the beach is a hill with a slight elongation to the northwest and has been modified by a nearby stream. The gravel pit has an exposure of about 12 feet, but the lower eight feet is covered by slump. The top is stratified into layers about one foot thick, with the upper three feet mostly coarse material up to 30 or 40 mm. in diameter. The lower material is medium sand, slightly stratified. The sample taken here is a five foot vertical channel sample.

The coarser material is rounded with a few subrounded and well rounded particles. In the 1/8 to 1 mm. in diameter range the sand is angular to subrounded with some rounded to well rounded. The sphericity is up to 0.9. No shale is present in the sand, which is 58 percent quartz.

The heavy minerals, 6 percent by weight, which were found are: magnetite, ilmenite, hyalophane, amphibole,

TABLE V. Data for Mechanical Analysis for Sample No. 5.

Tyler Screen	Weight Retained on Screen	% by Weight
5 mesh	370.03 grams	51.26
9	41.10	5.69
16	53.60	7.43
32	88.00	12.19
60	66.60	9.23
115	81.23	11.25
250	9.28	1.29
Pan	12.00	1.66
Total	721.84 grams	100.00

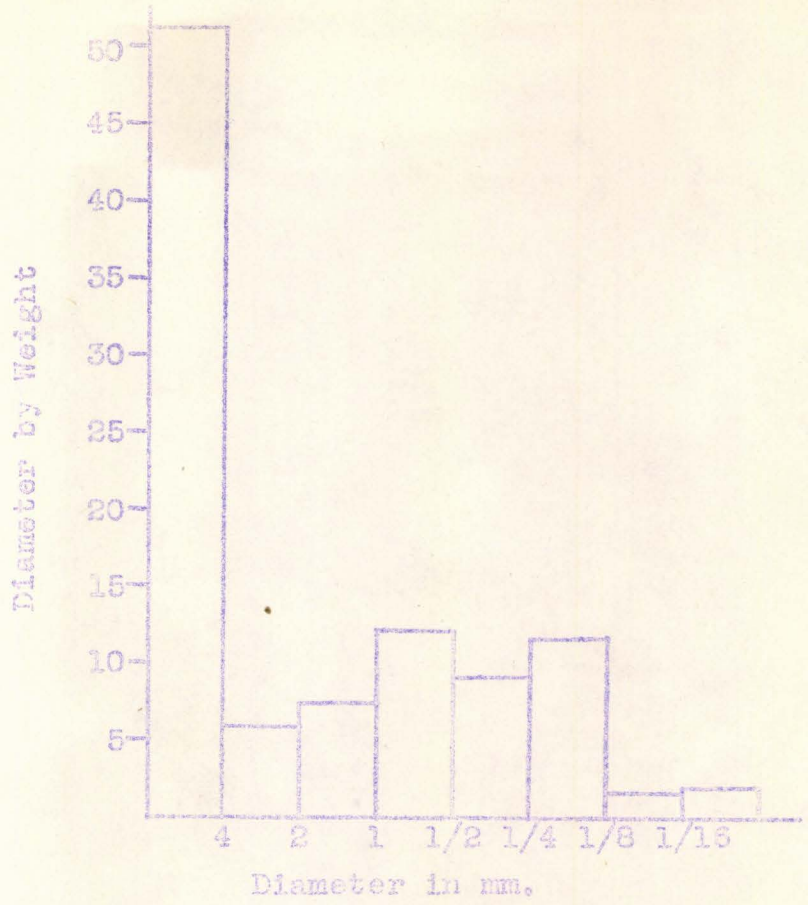
biotite and tourmaline. The light material is: quartz, quartzite, and igneous rock fragments.

Sample No. 6, a three foot vertical channel sample, is from the NW¼, SW¼, Sec. 6, T. 151 N., R. 53 W., (Fig. 2), at an elevation of 1000 feet. Here the beach is a low ridge that, in places, grades into the lower, McCauleyville, beach. This gravel pit is shallow, but covers a large area.

TABLE VI. Data for Mechanical Analysis of Sample No. 6.

Tyler Screen	Weight Retained on Screen	% by Weight
5 mesh	174.50 grams	40.60
9	75.45	17.55
16	47.13	10.97
32	30.78	7.16
60	41.10	9.56
115	51.48	11.98
250	4.55	1.06
Pan	4.80	1.12
Total	429.79 grams	100.00

The beach is crudely stratified with pebbles up to 60 mm. in diameter scattered throughout. The coarse



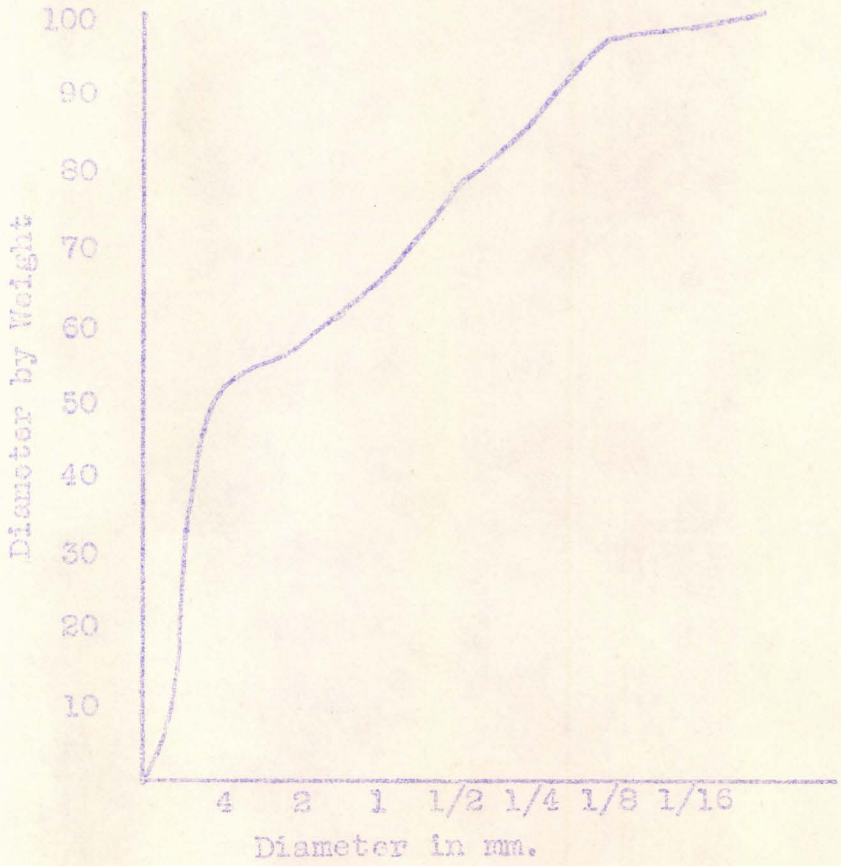
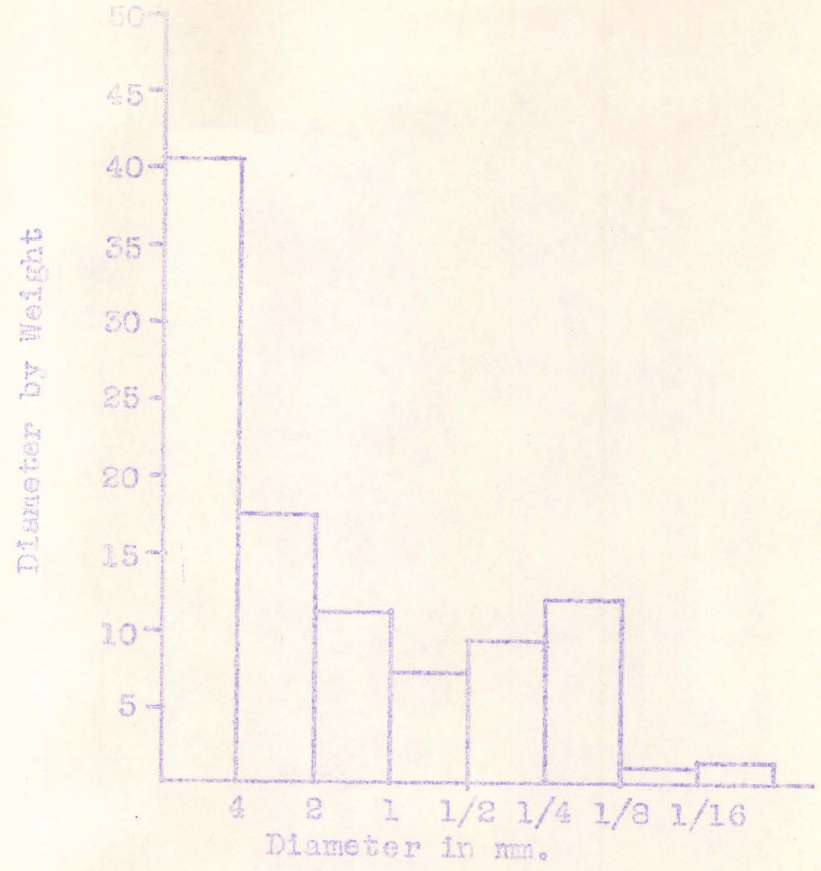


Fig. 7. Histogram and Cumulative Curve of Sample 5.



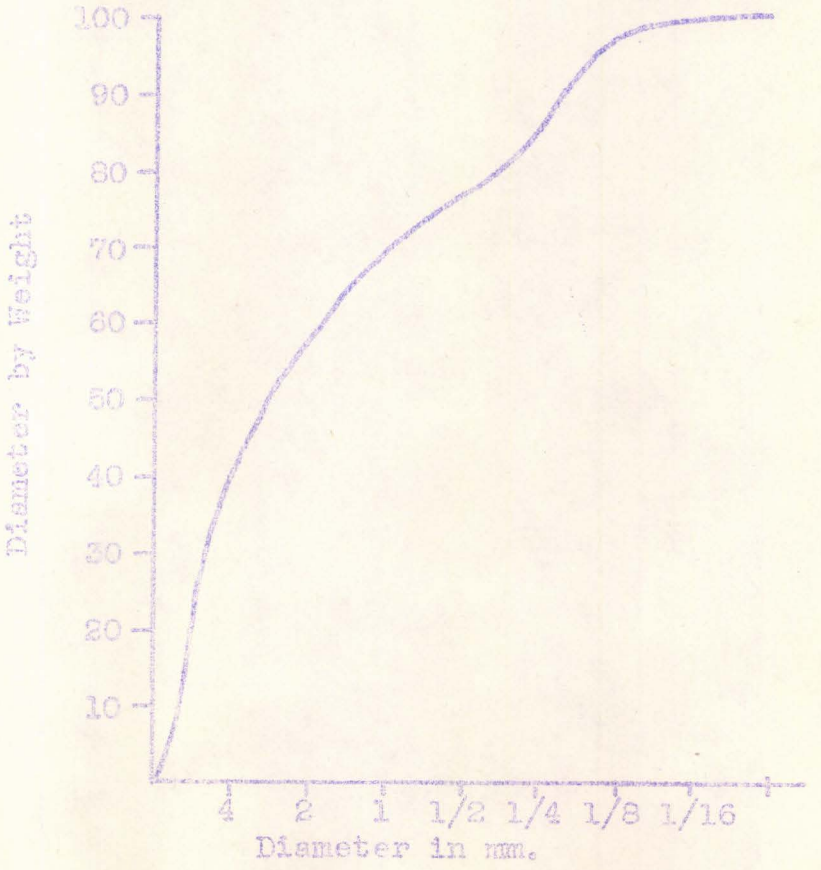


Fig. 8. Histogram and Cumulative Curve for Sample 6.

material is subrounded to well rounded. The material in the 1/8 to 1 mm. size is angular to subrounded and well rounded. The sand is composed of 64 percent quartz; no shale was found.

The heavy minerals, four percent by weight, found are: magnetite, ilmenite, hyalophane, biotite, tourmaline, and amphibole. The light material is: quartz and igneous rock fragments.

SUMMARY AND CONCLUSIONS

The main difference noted between the two beaches in this area is the lack of shale in the sand of Campbell beach. There is more coarse material in the Campbell beach, but the gravel in the Herman beach runs a little larger in size.

The heavy minerals found in the two beaches are the same, with the only outstanding feature being the presence of the rare barium feldspar, hyalophane.

The clay bed noted in gravel pits 2 and 3 could not be traced northward to the first gravel pit. This seems to indicate that it may have been caused by local flooding.

From the scope of this report the two beaches can not be differentiated by mechanical analysis alone, and more detailed work will have to be done over a larger area in order to distinguish between the two with preciseness.

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